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Effect of Bioinoculents on Growth, Yield and Fibre Quality of Cotton under Irrgation

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Abstract: Field experiment was conducted at Marathwada Agriculture University, Parbhani (M.S., India) to study the effect of bioinoculents on cotton. A co-cultured formulation of *Azospirillum*, Phosphorus solubilizing bacteria (PSB) and Pink Pigmented facultative methylotrops (PPFM) was used as bioinoculants in cotton. Plant Growth Parameters of shoot and root, Yield Parameters and fibre quality parameters were determined. Better growth and high yield of cotton was obtained by using bioinoculents. Inoculation of *Azospirillum*, PSB and PPFMs along with chemical fertilizers resulted in to the significant increase in growth parameters of cotton. The superiority of Surat strain of *Azospirillum* + PSB + PPFM was evident at all the fertilizer level. The uses of bioinoculents are beneficial in improving the fibre quality up to some extent.

Key words: *Azospirillum*, bioinoculants, Phosphorus solubilizing bacteria, Pink Pigmented facultative methylotrops.

INTRODUCTION

Cotton is one of the most important commercial crops in India and occupies a major source of foreign exchange. It is an important raw material for textile industry and ginning industry. Water and nutrients are essential requirements for the crops to grow. Nutrients may be of organic or inorganic in nature. Inorganic fertilizers are costly and cause environmental problems. Use of organic fertilizers alone can not meet the nutritional requirement of the plant [1]. So combined application of organic and inorganic fertilizers are required which is called as integrated plant nutrient system to maintain and increase the soil fertility as well as to increase the crop production. Bioinoculants constitute an important component in integrated plant nutrient system. It is an added advantage when these microbial inoculants are supplied through biofertigation as it has more water use efficiency and fertilizer use efficiency, quality etc. Effective microorganisms can also be applied in the filed along with organic or inorganic materials [7]. The organic and biological sources of nutrients provide essential nutrients to the crop and also enhance the positive interaction with chemical fertilizers by increasing their efficiency [1]. Beneficial bacteria such as *Azospirillum*, phosphobacteria and methylotroph colonizing in the rhizo sphere region and has the ability to fix nitrogen, solubilize phosphorus and stimulate plant growth. Methylobacterium sp. on coinoculation with Rhizobium sp. TNAU14 had significantly increased plant growth, nodulation and yield attributes in groundnut compared with individual inoculation [12]. The biofertigation can precisely deliver the bioinoculants in the root zone. However this technology needs to be standardized as the literature availability related to biofertigation is very scarce. The present study was undertaken to evaluate the performance of bioinoculants under field condition on cotton.

MATERIALS AND METHODS

A field experiment was conducted on Research farm, department of Agronomy, College of Agriculture, Marathwada Agriculture University, Parbhani, during winter irrigated season of 2004-05 on irrigation in intraspecific cotton cultivar PH-348. The experiment was laid out in a randomized block design and replicated thrice. The following treatments were used in this study.

T0 – Without bioinoculent
T1 – *Azospirillum* Surat strain
T2 – PSB TNAU
T3 – PPFM (Seed inoculation + Phyllasphere spray)
T4 – *Azospirillum* Surat strin + PSB TNAU
T5 – *Azospirillum* Surat strin + PPFM

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T6 – PSB TNAU1 + PPFM
T7 – *Azospirillum* Surat strin + PSB TNAU1 + PPFM
T8 – 100% N, P and K.

Treatment of Seeds: The *Azospirillum* strain from Surat, and one available with the department was tested along with effective microorganism (EM) cultures, collected from Department of Agricultural Chemistry and Soil Sciences (ACSS), Marathwada Agriculture University, Parbhani (M.S., India). The bacterial suspension having a count of 1 07 CFU/ml. was added at the time of sowing just over the seed @ 2ml/hill.
The PSB strain from TNAU, Coimbatore and one available with the department was tested along with effective microorganism (EM) cultures, collected from Department of ACSS, Marathwada Agriculture University, Parbhani (M.S.). The bacterial suspension having a count of 107 CFU/ml. was added at the time of sowing just over the seed @ 2ml/hill.

The PPFM strain from TNAU, Coimbatore and one available with the department was tested along with effective microorganism (EM) cultures, collected from Department of ACSS, Marathwada Agriculture University, Parbhani (M.S.). The bacterial suspension having a count of 107 CFU/ml. was added at the time of sowing just over the seed @ 2ml/hill.

Three most efficient *Azospirillium* strains were used for inoculation of seeds. A strain of phosphobacteria isolated and found most effective, was used for inoculation along with *Azospirillium* strains and plant growth promoters producing organisms like pink pigment facultative methylotrophs (PPFMs). The bacterial suspension having a count of 107 (CFU/ml) was added at the time of sowing, just over the seed on each hill @ 2ml/hill. Apart from these treatment, the PPFM was also was also applied as phyllosphere spray on 45^{th} and 90^{th} day of crop age.

Sowing was done by dibbing at row to row 60 cm and plant to plant 30 cm spacing by placing to seeds at each hill. After germination, one plant per hill was maintained. Irrigation was given as per requirement of crop. Standard plant protection schedule was followed to protect the crop from diseases and pests.

Preparation of Standard Inoculum: The standard inoculums was prepared by inoculating log phase cultures of bioinoculants viz., *Azospirillum* in N-free malic acid broth, PSB in pikovskya's broth and PPFM in Ammonical mineral salt (AMS) broth.

The observations on different growth parameters were recorded on 45, 90 and 135 DAS. The length of shoot was adjusted by taking the physical count of the length of the shoot from color region to apical bud. Length of root was adjudged by taking the physical count of the length of root from color region to tip of the tap root. The fresh root and shoot samples were measured physically on top loading balance and resulting weight were recorded as shoot and root fresh weight in gram. The dry matter accumulation by root and shoot was recorded by subjecting the root and shoot to oven drying at 60^0C till the constant weight and physical weight was recorded.

Five plants were sampled for recording the boll weight on 90 DAS. Five bolls were selected randomly each from top, middle and lower portion of cotton plant. These bolls were picked out and weighted on physical balance and the average weight so obtained was recorded as weight of bolls. While for boll number total numbers of bolls on each plant were counted physically and average numbers of bolls were recorded as number of bolls. The representative sample of around 11 0g of cotton lint each from all treatment and replication was drown and sent to CICR laboratory, Athwa farm, Surat (India) and data on fibre quality parameters was drown.

The data on growth parameter and cotton seed yield was subjected to statistical significance as per procedure given by Panse and Sukhatme (1967). The critical differences at 5 percent level were reported, whenever necessary, for interpretation.

RESULTS AND DISCUSSION

Plant Growth Parameters: The effect of inoculation of bioinoculants on plant height and root length of cotton was studied and data are presented in Table I. The data clearly indicated that the plot receiving Surat strain of *Azospirillum* + PSB + PPFM with 75% recommended dose of fertilizer (T7) Showed maximum shoot length i.e. 46.00, 166.33 and 141 .67cm and highest root length i.e. 20.33, 38.33 and 39.66cm on 45, 90 and 135 DAS respectively.

The outcome of inoculation of bioinoculants on plant fresh shoot weight and that of root of cotton was studied and data are obtainable in Table I. The data evidently indicated that the plot getting Surat strain of *Azospirillum* + PSB + (T4) among 75% recommended dose of fertilizer exhibited maximum fresh shoot weight i.e. 441.00 and 593.00 cm and highest dry that weight i.e. 141.00 and 194.67g on 2nd and 3rd observation respectively. The product of inoculation of bioinoculants on plant fresh root weight and that of dry of cotton was studied and data are available in Table I. The data unmistakably indicated that the plot getting Surat strain of *Azospirillum* + PSB + (T4) along with 75% recommended dose of fertilizer exhibit maximum fresh root weight that is to say 24.33 and 34.66g and uppermost dry weight i.e. 9.33 and 13.60g on 2nd and 3rd observation respectively. The outcome of inoculation of bioinoculants on boll weight and balls

number of cotton was studied and data are presented in Table II. The data definitely indicated that the plot receiving 100% recommended dose of fertilizer put on view maximum boll weight that is 1 .97g and up most boll number (27) recorded in the plot receiving 75% recommended dose of fertilizer along with inoculation of Surat strain of *Azospirillum* + PSB + PPFM.

Yield Parameters: The seed cotton yield was recorded (Table II) in each plot after three pickings and has found maximum yield (3267 kg/ha) was recorded in plot receiving 75% of recommended dose of fertilizer along with inoculation of Surat strain of *Azospirillum* + PSB + PPFM. The effect of inoculation of bioinoculants on fibre quality of cotton presented in Table II. The span length of cotton fibre in different treatment ranged from 24.10 to 25.53mm. The maximum span length (25.53mm) was noted in the plot receiving Surat strain of *Azospirillum* + PPFM with 75% N, P and 100% K2O. Smallest span length (24.10mm) was note in the plot receiving PSB TNAU + PPFM with 75% N, P and 100% K2O. The uniformity ratio of cotton fibre harvested from different treatments ranged from 49.66 to 51.66. Greatest uniform ratio (51.66) was recorded in the plot receiving Surat strain of *Azospirillum* along with 75% N, P and 100% K2O. Least uniform ratio (49.66) was record in many other plots. The micronaire value of cotton fibre ranged from 4.66 to 5.00. The chief value is found in plot receiving 100% N, P and K2O while least value is found in plot receiving PSB TNAU + PPFM with 75% N, P and 100% K2O. The tenacity of cotton fibre in different treatment found largest (17.76 g/t) in the plot receiving Surat strain of *Azospirillum* + PPFM along with 75% N, P and 100% K2O while least tenacity (15 .90g/t) recorded in plot receiving Surat strain of *Azospirillum* along with 75% N, P and 100% K2O. Elongation percentage of cotton fibre (EIG %) in different treatment found highest (5.33 %) in plot receiving Surat strain of *Azospirillum* + PPFM along with 75% N, P and 100% K2O while lowest (5.00 %) in plot receiving Sutat strain *Aspirillum* + PSB + PPFM with 75% of recommended dose of fertilizer. The maturity with different treatment was very high and recorded as 81 to 82 in all treatment. Fertilizer application and / or combined inoculation seem to have no effect on maturity percentage of cotton fobre. The short fibre index (SFI) in different treatment found lowest (11.46 W) in plot getting Surat strain of *Azospirillum* along with 75% N, P and 100% K2O while uppermost (14.03 W) in plot receiving PSB TNAU + PPFM with 75% N, P and 100% K2O.

Discussion: The population of our country has already reached over 100 crore and will continue to increase creating additional pressure on our resources for food and fibre. To meet out the requirement of this ever increasing population, we need to increase our agricultural production. For this increased production the soil needs to be supplemented with required nutrients. Since the nutrients supply through the chemical fertilizers is becoming more or costlier, we are forced to find out alternate nutrient sources. The bio fertilizers is such an alternate source which needs to be exploited to its maximum potentials. These biofertilizers provides appreciable quantities of nitrogen and phosphorus at cheaper cost and without any pollution hazard and damage to soil health. Considering these beneficial effects of phosphorus solubilizers plant growth promoters and nitrogen fixers, the present investigation was planned to find out their effect on growth parameters, seed cotton yield and fibre quality of cotton under irrigated situation.

The shoot and root length of cotton plant recorded at periodic interval of 45, 90 and 135 DAS in field culture was increased with the application of chemical fertilizers. Amongst the inoculation treatment Surat strain of *Azospirillum* + PSB + PPFM with 75% of recommended dose of fertilizer brought about the maximum increase in the shoot and root length of cotton plants, which was significantly more compared to other treatments. Such beneficial effect due to inoculation of N-fixers and P solubilizers has been reported in the past. Mehandale [14] reported the increase the plant height in sorghum with the application of *Azospirillum.* Similar reportes have been reported by Kulhare *et al*. [11], Dubey [4], Wange *et al.* [29], Patil, [17] and Shitaphale, [24].

The fresh and dry shoot weight of cotton plant was significantly improved with the application of culture chemical fertilizers. Amongst the inoculation treatment Surat strain of *Azospirillum* + PSB along with 75% of recommended dose of fertilizer brought about the maximum increase in the shoot biomass of cotton plants significantly more compared to other treatments and control. The result obtained in the present investigation is in agreement with those reported in the past. Smith *et al.,* [25] reported significant increase in shoot biomass accumulation of peal millet plant when inoculated with *Azospirillum lipoferum.* Mehandale [14] obtained the more plant biomass in sorghum with the inoculation of *Azospirillum.* Similar results have been reported by Alagawadi and Gour [2], Kavimandan and Gaur [10], Singh and kapoor [23], Gunasekaran and Sivakumar [6], Wang Chunli *et al.* [28], Gitte [5], Sitaphale [24] and Kadam [8].

The fresh and dry weight of cotton root was significantly enhanced with the application of culture chemical fertilizers in pot culture. Maximum root biomass was obtained in the plot receing 75% of

recommended dose of fertilizer with inoculation of *Azospirillum* + PSB. This trend in increase in root biomass was seen 2nd and 3rd dates of observations. The increases in root biomass of cotton obtained in the present investigation are in full agreement with those reported in the past, Tien *et al.,* [26] reported increased growth of root of pearl millet with *Azospirillum* inoculation. Similar results have been reported by Rani *et al.,* [19], Wange Chunli [28], Gitte [5], Sitaphale [24] and Kadam [8].

The number of bolls per plant and average weight of bolls were significantly increased with the application of chemical fertilizers. Maximum number of bolls and highest boll weight was obtained from the plots inoculated with Surat strain of *Azospirillum* + PSB + PPFM along with 75% of recommended dose of fertilizer brought the beneficial effect on the growth of the plant obtained in the present investigation are in full agreement with those reported in the past, Wani *et al.,* [30] observed consistent increase in grain dry matter and yield of some pearl millet cultivars when inoculated with

Azospirillum lipoferum and *Azospirillum brasilense.* Kulhale *et al.,* [11], obtained more number of pods per plant when soyabean was treated with PSB in combination with *Rhizobium.* Similar results have been reported by sharma and Namdeo [20], Gitte [5] Malligwad *et al.,* [13], Sitaphale [24] and Kadam [8].

The seed cotton yield obtained in the present investigation differed significantly and it was maximum in plots receiving 75%of recommended dose of fertilizer along with inoculation of Surat strain of *Azospirillum* + PSB + PPFM. The increases in yield of cotton obtained in the present investigation are full agreement with those reported in the past. Smith *et al.,* [25] and Wani *et al.,* [30] obtained increase yield of peal millet when inoculated with *Azospirillum lipoferum.* Mishra *et al.,* [15] reported 31% increase in grain yield of maize with inoculation of PSB. Similar results have been reported by Sharma and Parmar [21], Vendan and Subramanian [27] Sharma and Namdeo [20], Gitte [5], Sitaphale [24] and Kadam [8].

Though non-significant, still the bioinoculants improved the fobre quality of cotton. The enhancement in fibre quality could not withstand the statistical treatment even though the increase was appreciable this necessitates in finding out a suitable treatment of such quality parameters. Maximum span length (25.53) was reported in the plot receiving Surat strain of *Azospirillum* + PPFM along with 75% N,P and 100% K2O, which are classified as good quality fibre. The results obtained in the present investigation are in agreement with those reported in the past. Cassman *et al.,* [3], Phipps *et al.,* [18], Mullins [16] and Kadam [8].

The maturity percentage was very high in all the treatments. Fertilizer application and/ or combined microbial inoculations seem to have no effect on maturity percentage of cotton fibre. Such effect has been reported in past. Shaw *et al.,* [22], Kadam [8].

The micronaire value was minimum in the plot receiving 75% N, P and 100% K2O along with inoculation of PSB TNAU + PPFM. Short fibre index (SFI) was lowest amount in the plots receiving 75% N, P and 100% K2O along with inoculation of Surat strain *Azospirillum.* Results with regard to these quality parameters with microbial inoculation has been reported by Cassman *et al.,* [3], Shaw *et al.,* [22], Kadam [8].

Conclusions: Inoculation of *Azospirillum,* PSB and PPFMs along with chemical fertilizers resulted in to the significant increase in shoot length of cotton. The interaction effect due to fertilizer and inoculation were significant on all dates of observations Surat strain of *Azospirillum* was proved superior at all fertilizer level. Investigation also indicated that inoculation of *Azospirillum,* PSB and PPFMs along with chemical fertilizers resulted in to the significant expand in fresh and dry shoot weight, root length, fresh and dry root weight, weight of boll and number of bolls in cotton. The seed cotton yield of irrigated cotton was significantly increased with the application of chemical fertilizers and inoculation of *Azospirillum,* PSB and PPFM. The superiority of Surat strain of *Azospirillum* + PSB + PPFM was evident at all the fertilizer level and was immediately followed by MAU strain of *Azospirillum*n + PSB + PPFM.

Inoculation of bioinoculants resulted in to the improvement of fobre quality. Span length, Uniformity ratio, Tenacity and EIG% were increased with application of chemical fertilizers and bioinoculants, while micronaire value and SFI were minimum with the application of N and P fertilizers and inoculation of *Azospirillum* + PSB + PPFM. Which are being considered as average type and good quality fibre respectively.

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Table 1: Effect bioinoculants on cotton in field culture observations.

T reatment	Length (cm)						Fresh Weight (g)						Dry Weight (g)					
	Shoot			Root			Shoot			Root			Shoot			Root		
	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS
T0	39.66	83.66	116.67	15.00	25.00	28.00	45.66	170.33	367.67	3.00	14.33	22.00	5.33	55.00	145.00	0.78	5.33	9.00
T1	43.66	108.67	127.67	16.00	21.66	31.00	45.66	326.33	465.33	2.66	16.66	27.33	5.00	120.00	153.67	1.02	5.66	10.33
T2	43.00	108.00	131.33	14.00	35.00	29.66	47.33	311.33	470.00	3.66	16.33	24.33	5.66	89.00	173.00	0.98	5.66	8.33
T3	36.66	115.00	130.00	17.00	33.66	36.00	56.00	347.00	521.67	4.33	18.66	24.00	6.33	133.00	166.67	1.07	7.33	7.33
T4	36.66	106.67	125.33	15.00	25.66	31.00	49.00	441.00	593.00	5.00	24.33	34.66	5.33	141.00	194.67	1.36	9.33	13.60
T5	43.66	114.67	132.33	12.33	43.00	36.00	56.33	269.33	412.00	5.00	18.33	20.33	6.33	95.66	142.67	1.51	7.00	8.33
T6	31.00	94.66	137.00	19.33	31.33	30.66	46.00	327.33	465.00	3.00	15.33	26.66	5.66	106.67	152.67	0.85	6.33	10.00
T7	46.00	166.33	141.67	20.33	38.33	39.66	55.33	207.00	449.00	4.00	15.00	24.00	5.66	65.00	136.33	1.39	6.00	10.00
T8	45.33	92.00	115.33	17.66	38.33	32.66	65.33	333.33	430.33	5.66	18.66	25.66	7.33	97.00	163.33	1.52	8.33	10.00
SE	1.64	2.85	4.39	0.84	2.06	1.79	2.94	13.65	23.59	0.40	1.18	1.36	0.33	5.77	8.68	0.08	0.56	0.83
CDat 5%	4.91	8.54	13.15	2.52	6.19	5.37	8.82	40.87	70.62	1.19	3.54	4.09	0.96	NS	25.99	0.26	1.67	2.48

SE, Standerd error. CD, Critical difference

Table 2: Effect bioinoculants on cotton in field culture observations.

Treatment			Seed Cotton yield			Fibre quality Parameters						
	Weight of boll (g)	No. of bolls per plant	g/plant	kg/plot	Kg/ha	2.5% span length (mm)	Unifor mly ratio	Micro naire	Tenacity (g/t) 3.2 value	EIG %	Maturity mm	SFI (W) ratio
T0	1.93	18.00	16.33	0.979	2312.52	24.83	51.00	4.90	17.03	5.30	82	12.03
T1	1.88	22.00	19.33	1.159	2675.17	24.66	51.66	4.83	15.90	5.26	81	11.46
T2	1.83	21.00	17.50	1.050	2416.67	25.33	50.00	4.96	17.10	5.30	82	11.76
T3	1.84	20.00	16.83	1.009	2326.40	25.13	49.66	4.86	16.16	5.00	81	12.26
T4	1.82	25.00	23.34	1.400	3267.00	24.13	49.66	4.70	16.50	5.06	81	13.80
T5	1.81	22.00	17.83	1.069	2481.50	25.53	49.66	4.73	17.76	5.33	82	12.20
T6	1.83	20.00	16.67	1.000	2317.15	24.10	49.66	4.66	17.10	5.20	81	14.03
T7	1.87	27.00	23.50	1.410	3245.00	24.53	50.00	4.73	15.93	5.00	81	13.06
T8	1.97	24.00	23.33	1.399	3235.00	24.63	49.66	5.00	17.10	5.23	82	13.33
SE	0.017	1.11	1.06	0.064	59.24	0.56	0.74	0.15	0.71	0.13	0.5	0.88
CDat5%	0.052	3.34	3.20	0.192	177.34	NS	NS	NS	.NS	NS	NS	NS

SE, Standerd error. CD, Critical difference. EIG, Elongation percentage of cotton fibre.SFI, short fibre index

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